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SCIENCE

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FRIDAY, FEBRUARY 15, 1901.

PHYSICS AND FAITH.*

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Our knowledge concerning the properties of and changes in matter is gained in the first place through our bodily senses, and secondly through the intellect; the primary concepts thus acquired are confirmed, modified and enlarged by operations of the imagination and of the reason. The five senses with which we are endowed are of very unequal value in the acquisition of knowledge of natural objects; smelling, tasting and hearing make but small and unimportant contributions compared with those communicated by the senses of sight and of feeling.

An intelligent being, having only the single sense of feeling, would nevertheless be able to handle a large number of objects within his reach and to study their properties; he would early distinguish between matter at rest and matter in motion; he would notice the properties of inertia and of weight; he would perceive in his person the effects of heat and of cold, of dryness and of moisture; he would become acquainted with the shape of bodies of moderate size and with their superficial properties, such as smoothness or roughness, softness or hardness; he might, if he made sagacious use of his one power, recognize the distinction between matter in its three states—solid, liquid and

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* Address of the retiring President of the Chemical Society of Washington, February 14, 1901. -

gaseous, though it would be difficult for him to comprehend their relations to one another. Air in motion makes itself felt, but of gaseous matter in general his knowledge would be very limited and vague. The simplest of tests would make him acquainted with elasticity, malleability and ductility, as well as with density and tenacity; fusibility and solubility would undoubtedly greatly puzzle him, and he would of course remain ignorant of light, of sound and of the physical universe beyond his limited sphere.

If to this being of one sense the so-called 'chemical senses' of taste and of smell were added, he would acquire greater insight into the special qualities of bodies that affect these organs; he would observe the agreeable odors of the natural products of the soil and forest as well as the offensive ones in the three kingdoms of nature; he would learn to differentiate many gases previously regarded as identical; he would learn to distinguish between alkaline and acid, sweet and bitter substances, and to recognize those having particular flavors. On the other hand, the intelligent being of three senses would fail to comprehend the physiological processes by which the sensations are perceived, and in this respect he would be little less ignorant than are beings of five senses.

On endowing this imaginary person with the sense of hearing his knowledge of the external world would be greatly enlarged and his personal comfort increased, he would also acquire a more exact knowledge of some of the properties of matter; he would become conscious of vibrations in the air conveying sounds, and by listening to the roar of a Niagara or to the chirp of a cricket, to the melodies of song birds or to the fierce growl of a beast of prey, he would attain to more lofty ideas of the marvels of nature than in his deaf state. He could now learn of the crackling of brimstone, the 'cry' of

tin, the snapping of electric sparks, and the startling detonations caused by combustion of 'villainous saltpetre' and of certain gaseous mixtures.

If finally, the precious gift of sight should be bestowed upon the subject of four senses a new world would be opened to him, and his intellectual and emotional capacities would be enhanced immeasurably; for the first time he would be able to realize the full meaning of the word beautiful as applied to nature. With the fifth sense he would perceive the beauty of form, of color, of luster, of ornamentation in the flower, the bird, the insect, the floating clouds and in the rainbow; he would have opened to him the magnificent spectacle of a starry firmament, of an aurora and of the sun in its noon-day glory. He would now be fairly equipped for investigating physical science.

At a remote period *seven* senses were attributed to man; these are given by the Hebrew author of the ancient book Ecclesiasticus as seeing, hearing, tasting, feeling, smelling, understanding and speech. They are referred to by the poet Pope in the couplet:

"Good sense which only is the gift of Heaven,
And though no science, fairly worth the seven,"

and the idea survives in the singular phrase in common use: 'Frightened out of one's seven senses.'

The nature of a sixth sense has been a matter of speculation, but it is hardly less difficult for individuals with five senses to form a conception of an extra sense, than it is for a sightless person to acquire any adequate idea of the true significance of seeing. The sixth sense has been called the muscular sense as distinguished from touch, but we prefer to think of it as a sense for cognizing forms of energy whose seat of action lies in the ether supposed to pervade space.

While it is absolutely impossible for a finite mind to plan the structure of an or-

gan that would give us this power or to conjecture its mode of action, in discussing it, we find it convenient to use terms analogous to those that we employ for the eye. We need, then, a keen sense that will enable us to 'see' what takes place in the interior of masses in their several states of aggregation; to 'see' the arrangement of the atoms within the molecule, and to study their behavior under the influence of well-known as well as obscure forms of energy. Even as Röntgen rays force a passage through the intermolecular voids of certain kinds of masses, a sixth sense might enable us to 'see' the action of heat in separating the molecules and the influence of chemism in uniting or in parting the atoms within them; to perceive the mechanism of solution, to 'see' the infinitesimal particles of sodium chlorid penetrate the aqueous liquid to form a homogeneous solution. To 'see' the exact manner in which an electrical 'current' (so-called) exerts its separating power when brought to bear upon a liquid; to test whether the theory of ionization has any substantial foundation. A sixth sense might permit us to 'see' the energy manifested by the Hertzian waves which under the skilful management of Marconi are just beginning to serve the interests of man; to learn the secrets of that medium permeating interstellar and intermolecular space which becomes the adjunct of sight; the art of photography has made visible views of the interior of masses impermeable to rays of light and has yielded permanent records of the sound waves of the air, but we seem to need a sixth sense to cognize the operations of the luminiferous ether.

In the fantastic conception in which we have indulged the imaginary being is supposed to be intelligent, for mere sense-perception without the cooperation of the intellect could not augment one's knowledge of the physical universe to any great extent.

Through our bodily senses we learn the existence of natural phenomena, but it is through operations of the intellect that we acquire the deeper knowledge which becomes the subject of imagination, of reason and, eventually, of faith.

After observing that some kinds of matter suffer changes in form, in properties, in potential energy when subjected to the influence of heat, of light, as well as to the action of other kinds of matter, and that certain causes produce uniformly identical results, thinking men made endeavors to explain the phenomena by inventing hypotheses as to the essence of the material objects and of the various kinds of energy acting upon them. In the infancy of learning, Greek philosophers of wonderful intuition conceived a theory of the constitution of matter that has made a lasting impress on physical science; the theory possessed marvelous adaptability, and when a Manchester schoolmaster grafted upon the aged trunk the tender shoot of his genius, it soon grew to be a vigorous branch that bore fruit of unsuspected value. Nearly a century has elapsed and the atomic theory has secured a strong hold upon the minds of physicists and of chemists; maintained by men of sound judgment and great authority, imparted by teachers of recognized ability to successive generations of pupils, it has become a matter of belief, adopted with a few exceptions by scientists throughout the enlightened world, and in their hands it has become a potent factor in the progress of physical science. Yet this theory is purely a figment of the imagination and makes extraordinary assumptions difficult of credence; it supposes that matter is made up of very minute particles, indivisible, indestructible, and unchangeable, separated from one another by void spaces larger than the particles themselves; these diminutive atoms are of definite, uniform and constant figure, and are in perpetual motion in all

conceivable directions at exceedingly high rates of speed; moreover, the atoms composing the different chemical elements are of determinate weights corresponding to their equivalents of combination; these minute particles attract each other with varying degrees of strength and unite in simple ratios to form larger particles called molecules; agglomerations of these molecules constitute masses, visible to the eye and subject to the laws of mechanics.

Faith in this purely intellectual conception has enabled men of genius to refer to it the explanation of many facts, and the hypotheses resulting have developed into laws of prime importance in chemical philosophy; Dalton discovered facts in the union of chemical bodies whose interpretation he found in the doctrine of atoms; Humboldt and Gay-Lussac reinforced the Daltonian laws by their labors on the ratios in which the volumes of gases combine; Avogadro, by purely physical researches established the relation between the volumes of gases and the number of their constituent molecules; and Gerhardt, working in the field of organic chemistry, observed the bearing of these discoveries on chemical philosophy and, by clearly establishing the distinction between atom and molecule, gave to the atomic theory its modern aspects.

Faith in this theory has made it possible to devise a scheme of notation that in spite of its defects has proved of great utility in promoting the advancement of chemistry; the multitudinous problems of stoichiometry, the modern theories of solution and of electrolysis, the doctrines of isomerism and of stereo-chemistry are achievements of the intellect and of the reason based upon a belief in an imaginary condition of matter. To crown the whole, Newlands, the Englishman, originated, Meyer, the German, and Mendeléeff, the Russian, brought to a high state of perfection, the Periodic law which has given to chemistry that prophetic power,

long regarded as the peculiar dignity of its sister science, astronomy.

Quite apart from these abstract principles, based upon a belief in the atomic constitution of matter, is the practical side of the question, of which the analytical chemist avails himself in determining the value of substances submitted to him; on the results of his figures thousands of dollars may change hands in the manufacturing, mining and commercial world. A ship-load of material is bought and sold on the result of the analysis of a sample conducted by a chemist, who bases his procedure on the supposed numerical relations of the invisible, intangible, immeasurable particles he calls atoms and in his calculations he relies on the constants determined by others, in whom he has confidence, and the accuracy of which constants he has to accept on faith. Reliance on the *dicta* and *data* of investigators whose very names may be unknown lies at the very foundation of physical science, and without this faith in authority the structure would fall to the ground; not the blind faith in authority of the unreasoning kind that prevailed in the middle ages, but a rational belief in the concurrent testimony of individuals who have recorded the results of their experiments and observations, and whose statements can be verified.

This faith in the fundamental principles of physical science persists notwithstanding it encounters insurmountable difficulties. Many problems defy the efforts of materialistic philosophers to solve them; the origin of matter and of motion; the initial source of energy as well as the relation of gravitation to other forces; the positive nature of the interstellar ether imagined as a vehicle for the transmission of light, not to mention proofs of its existence; the true inwardness of actinism, of Röntgenism, and of the rays named after Becquerel; the ultimate identity in es-

sence of the so-called elementary bodies. Some of these problems will undoubtedly be solved as knowledge of the material world increases, but others are destined to remain inscrutable to finite minds and as such may be called scientific 'mysteries.' We can construct ingenious arguments based largely on assumptions, and reason ourselves into the notion that our hypotheses explain the questions at issue, but after all we know very little beyond the effects observed.

These problems arise in every department of organized knowledge; the student of chemistry does not have to look far afield to encounter mysteries, though he does not commonly so style them; phenomena of ordinary experience challenge the interpretation of philosophers. What do we actually know of the chemical force called affinity? Who can tell why the attraction between A and B is so much stronger than between A and C, or why one element forces another out of its combination with a third? What chemist who has watched under the microscope the beautiful, symmetrical manner in which minute particles of a substance separating in solid form from solution, arrange themselves in geometrical figures obeying well established mathematical laws, can pretend to explain the cause of the astounding behavior of the inert, lifeless matter?

But I desist from propounding further queries, the answers to which are buried in impenetrable mystery. A student of elementary chemistry, impressed with the ability of the teacher to explain natural phenomena, asked him: 'Professor, why is gold yellow?' Whereupon the professor, waiving the customary explanation [?], reverently answered: 'Because God made it so!'

Is it unfair to scientists to say that they sometimes take refuge in obscure language to veil their ignorance? It may help our

imagination to affirm that carbon and other elements occur in 'allotropic' forms, but does this statement adequately explain the phenomenon? To term the peculiar action of certain bodies, which themselves suffer no change while they effect decompositions or combinations in others with which they are brought in contact, as 'catalytic' may be soothing to the mind, but is it scientific? Is it satisfactory? One hundred and fifty years ago the properties of water were said to be caused by its 'aquosity'!

In this study we have confined our illustrations to the physical and chemical branches of science, but they might well be drawn from astronomy and from the biological sciences; in the former, one becomes acquainted with

"Realms yet unrevealed to human sight,"

as well as with the conception of infinity in space and in time; in the latter, one encounters the unfathomable mystery of the origin of life. It is evident that in pursuing any branch of knowledge the seeker has opportunities of familiarizing himself with ideas contained in the phrases, 'invisible world,' 'infinity,' 'mystery,' and with facts that require application of all the powers of the imagination and of reason, to grasp which he exercises faith.

Most scientists having this mental training, in which acts of faith are demanded at every step, find it natural to apply this faith to their hypostasis of the spiritual world; they thus acquire belief in an inscrutable Divine Being, who exercises almighty wisdom and power in the guidance of the material universe, and who has made Himself known to humanity by revelation. To such persons it does not seem more difficult to believe in spiritual force and its influence on mankind, than to believe in the existence of energy and its effects on matter. Huxley, who certainly can not be accused of religious bias, is said to have

remarked: "The doctrine of the immortality of the soul is not so wonderful as that of the conservation of energy or of the indestructibility of matter."

The evidence of the existence of spirit is precisely analogous to the evidence for matter; matter, as we have seen, is revealed to us only as its phenomena, extension, weight, color, behavior when subjected to heat, etc., affect our senses; of its essence we know nothing; spirit, likewise, is revealed to our consciousness through its powers of thinking, feeling and willing, but of the essential spirit the finite mind knows nothing. "Matter," writes an American scientist, "is the thing perceived, spirit the thing perceiving, matter is the passive, spirit the active principle. Without a belief in spirit, therefore, not only can there be no religion, no virtue, but there can be no philosophy or science. * * * The very origin of our notion of force is the consciousness of our own mental energy, and this universal energy of Nature is an effluence of the Divine Being."

Faith, both in science and in religion, is belief based on suitable evidence from sources outside of personal experience, both are fruitful in different ways, the former affecting the intellect and the latter the heart of man; scientific faith bears fruit in the steamship and in the telegraph, Christian faith in works of mercy and charity and in a life of love shown toward mankind and to God; it is

"The subtle chain
That binds us to the Infinite."

On the other hand, some students of science, accustomed to exercise faith in their attempts to solve obscure problems in the material world, hesitate (and a few refuse) to extend this intellectual power to the spiritual universe; this is undoubtedly due to the operation of the will, for

"A man along that road is led
Which he himself desires to tread."

The supreme goal of the student of science was admirably conceived and expressed in a single sentence by the renowned Kepler, when he wrote nearly three centuries ago:

"The scientist's highest privilege is to know the mind and to think the thoughts of GOD!"

H. CARRINGTON BOLTON.

WASHINGTON, D. C.

*THE SOCIETY FOR PLANT MORPHOLOGY
AND PHYSIOLOGY.*

THE Society met, together with the American Society of Naturalists and the Affiliated Societies, at Johns Hopkins Medical School, Baltimore, Md., December 27-28, 1900, under the presidency of Professor D. P. Penhallow. There was a large attendance of members, and the meeting was in all ways profitable and successful. The presidential address dealt with 'A Decade of North American Paleobotany'; it was published in this Journal for February 1st. The most important business of general interest was the presentation of the report of the Committee (Messrs. Farlow, MacDougal and von Schrenk) appointed to consider methods of securing improvements in reviews of current botanical literature. Copies of the report were distributed to members present, and have been sent to other botanists throughout the country. It shows a completely successful result of the Committee's work, and comments upon it will appear later in this Journal. A committee was also appointed (consisting of Messrs. Ganong, Lloyd and Atkinson), to take into consideration the formulation of a standard college entrance option in botany. On Saturday, December 29th, the members of the Society, with guests, made an excursion to Washington, where they were shown the work of the Department of Agriculture, and were received by the Honorable Secretary for Agriculture,